A NON-TORNADIC SPIRAL-SHAPED RADAR ECHO[1]

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ABSTRACT

A spiral-shaped radar echo, apparently of non-tornadic origin, was observed over southwestern Alabama on the afternoon of July 1, 1959. A series of scope photographs of the CPS–9 radar at Maxwell Air Force Base shows that this feature persisted for well over an hour and suggests that the pattern was experiencing anticyclonic rotation.

1. INTRODUCTION

During the afternoon of July 1, 1959, an unusual spiral-shaped radar echo of rather small dimensions was observed over southwestern Alabama on the AN/CPS–9 radar at Maxwell Air Force Base, Montgomery, Ala. Special attention was devoted to this radar feature since in several cases tornadoes have been found to be associated with hook- or spiral-shaped echoes ([1, 2, 3]). In this instance, however, no evidence could be found that would indicate that tornadic conditions existed in the vicinity of the unusual echo. This feature persisted for a period of nearly 2 hours and at its point of greatest organization (fig. 1) was not too dissimilar, as far as size and shape, to the echo associated with the Worcester, Mass. tornado of June 9, 1953 [1]. The total vertical extent of the echo, as discussed below, was much less than found in most of the tornado-producing systems.

During the period of its existence, the spiral-shaped echo shown in the successive parts of figure 3 moved about 55 miles toward the west-northwest. It did not pass close to any first order weather stations and there were no special reports of tornadoes, hail, or damaging winds appearing on the weather circuits. Additional evidence was sought from a questionnaire mailed to U.S. Weather Bureau cooperative observers on the day after this echo was observed. The only instances of severe weather revealed by this survey were reports of hail at some distance to the right and left of the track of the echo. Light hail was reported at Brewton between 1400 and 1500 CST and hail fell "during the afternoon" 6 miles southwest of Minter (fig. 2). A visit to the area of interest was made by Major Kitzman of the Maxwell AFB Weather Detachment about a week after the echo was observed, but his conversations with a number of individuals in the area uncovered no new evidence. The rainfall records for southwestern Alabama, as discussed below, show that precipitation was very light on July 1 in the western portion of the area traversed by the spiral echo.

Since well-defined vortices or spiral echoes of the type shown on the Maxwell AFB CPS–9 on July 1, 1959 could

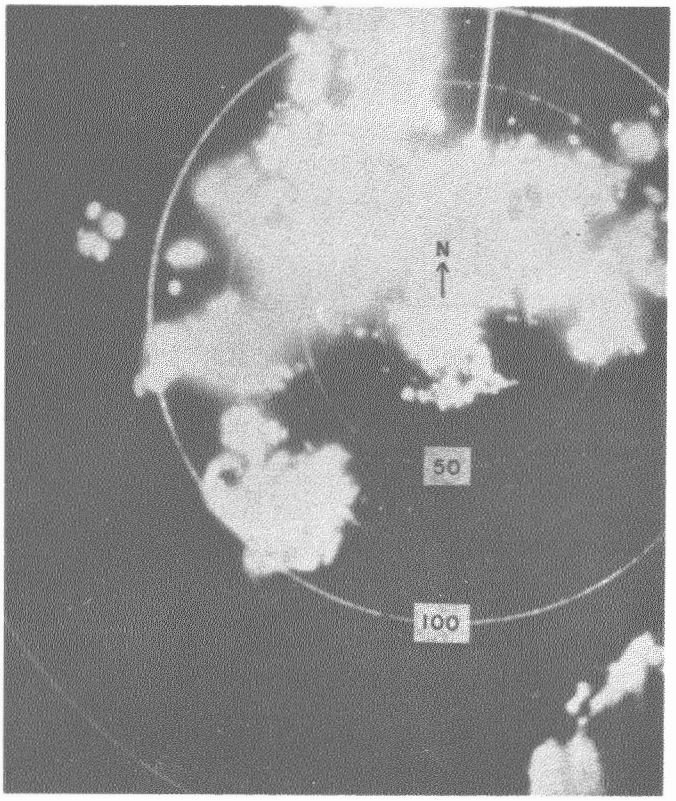

FIGURE 1.—A photograph of the Maxwell AFB CPS–9 PPI scope taken at 1501 CST, July 1, 1959. The spiral-shaped echo of interest is located about 90 miles to the southwest of the station. The set was on long pulse (5 microseconds) and the antenna was elevated one degree.

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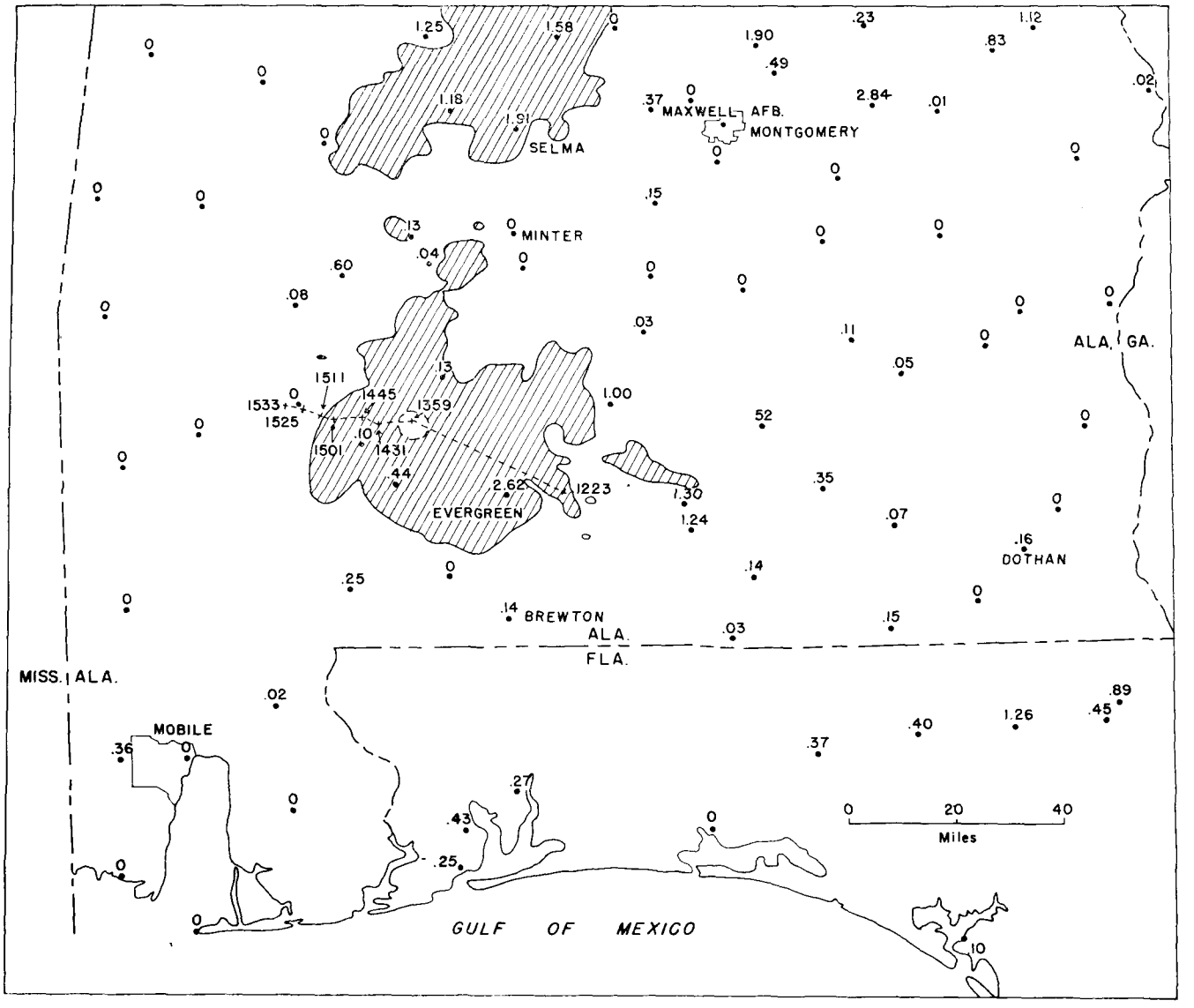

FIGURE 2.—The principal radar echoes observed by the Maxwell AFB CPS–9 at 1359 CST, July 1, 1959, (fig. 3b) are indicated by the hatched area. The track of the spiral-shaped echo is indicated by the dashed line with times given in Central Standard Time. The 24-hour precipitation amounts are shown (in inches) for all available stations. The precipitation totals are for 24-hour periods ending at several different times but all totals include the precipitation which fell during the afternoon of July 1, 1959.

possibly lead to false tornado alarms, it was felt that a careful examination of this case might prove of value. Accordingly, an attempt has been made to evaluate the available radar information in view of the existing weather conditions in the area and the characteristics of the radar set.

2. SYNOPTIC CONDITIONS

During the morning of July 1, 1959, a cold front extended from northern Indiana to western Arkansas with a relatively strong pressure gradient to the rear of the front. The pressure gradient in the warm air ahead of the cold front was weak over most of the southeastern United States with a north-south trough extending from Ohio to Florida. Shower activity was quite prevalent over the southeastern United States and a well-developed north-south line of thunderstorms formed about 50 miles west of Maxwell AFB during the morning hours of July 1. This line remained in approximately the same position during the afternoon (fig. 3) with scattered showers developing to the east of the line; these resulted in locally heavy rains in some areas northeast of Montgomery (fig. 2). A small tornado of short duration occurred near Craig AFB, Selma, Ala., at about 1100 CST. The radar echoes on the Maxwell CPS–9 were indicated to extend to 70,000 ft. in the vicinity of this tornado. There were no unusual hooks or spirals noted on the radar at the time of this tornado.

The spiral-shaped echo discussed in this report was in association with a well-developed complex of showers which developed during the early morning hours in the

vicinity of Evergreen (fig. 2). After remaining nearly stationary for several hours, this system moved to the west-northwest in opposition to the weak pressure gradient shown on the surface charts. Later in the afternoon this weakening echo tended to become aligned with the showers which had persisted in a line to the west of Maxwell AFB (fig. 3g). The motion of the radar echoes over southern Alabama was roughly parallel to the flow at the 500-mb. level and the north-south line of showers fell near a weak 500-mb. trough. At this level a col was located near Montgomery with westerlies to the north and easterlies to the south.

The heaviest rains over southern Alabama on July 1 were at Evergreen with 2.62 inches and at River Falls and Andalusia, some 20 miles to the east-southeast of Evergreen (fig. 2). The observations from the Federal Aviation Agency station at Evergreen show that the heaviest rain occurred between 0900 and 1000 CST during the time that shower area was nearly stationary. Light rain was falling at Evergreen as the center of the shower area passed to the north of the station (fig. 2) and continued until 1540 CST. Thunder, which had been reported continuously from 0556 CST, ended at Evergreen at about 1345 CST. The reported surface wind speeds at Evergreen were very light throughout the existence of the spiral echo. The observations made nearest the time of the spiral echo, at 1159 and 1255 CST, reported east 5 knots and east-northeast 6 knots. Higher wind speeds may have occurred between these observation times but special observations should have been recorded if the wind speed had increased to above 26 knots.

A spiral echo with a well-defined central "clear" area was first apparent on the radar scope at about 1400 CST and, by this time, the rainfall in the path of the shower area was relatively light (fig. 2). One station almost directly in the path of the echo during its dissipating stage reported no measurable rain (fig. 2).

3. THE SPIRAL-SHAPED RADAR ECHO

The shower area which spawned the unusual radar echo first attracted attention at Maxwell AFB about 1200 CST when some of the outer portions of the echo tended to take on a circular form centered about a small area of lighter return. At this time the echo was near Evergreen (figs. 2 and 3a). By 1430 CST, a clearly defined vortex echo with a "clear" center about 5 miles across had appeared on the scope (fig. 3c). This vortex was closely monitored as it moved west-northwest along the track shown in figure 2. During this period a series of scope photographs of the CPS–9 was taken with a Polaroid camera, a large portion of which are reproduced in figures 3 and 4. Most of the PPI photographs were taken on 200-mile range and the 100-mile range marker appears just outside the spiral echo. The expanded-scale off-center photographs (3h, j, k, and l) were taken during the dissipating stage of the echo and show but little more detail than those taken on the 200-mile range. Although the photographs were not taken at sufficiently short intervals to definitely establish details of the circulation, the patterns (cf. fig. 1) suggest that the detailed features within the vortex were circulating in the anticyclonic sense with a slight tendency toward indraft.

The rainfall data presented in figure 2 suggest that very little precipitation was occurring in the vicinity of the spiral echo during its last stages. The CPS–9 is a relatively high-powered set (250 kilowatts peak power) operating at a relatively short wavelength (3.2 cm.) and is, therefore, capable of detecting non-precipitating clouds in many instances [4]. The PPI photographs were all taken at approximately the same gain setting (8.0 on the linear 0–10 scale used on the CPS–9) and with the antenna elevated 1°. With this antenna tilt and with normal refraction, the center of the beam in the vicinity of the echo would have been located about 8,000 ft. above the tangent plane or about 13,000 ft. above the earth's surface. The width of the CPS–9 beam, as defined by the half-power points, is 1°, so that at 90–100 miles out the beam would have been covering a layer about 9,000 ft. thick. Therefore, the spiral echo shown on the radar photographs should be considered as arising primarily from hydrometeors in a layer from roughly 8,500 to 17,500 ft. above the earth's surface.

Range-height-indicator (RHI) scope photographs taken during the weakening stage of the echo at 1521 and 1545 CST (fig. 4) show clear areas corresponding to the vortex and indicate that the echo did not extend more than 20,000 ft. above the tangent plane or 28,000 ft. above the earth. Some reduction of this maximum altitude value should be made to compensate for the beam width since, as indicated above, the conical beam is covering a layer about 9,000 ft. thick at this range. The primary information provided by the RHI photographs is that the spiral echo was essentially vertical and extended from roughly 8,000 ft. to somewhat less than 25,000 ft. The vortex does not appear as distinctly on the later RHI photographs as on the earlier one and this change is consistent with the features of the PPI photographs (figs. 3h and 3j). RHI photographs are not available for the earlier stages of the spiral echo but during the late morning hours the radar echoes in the vicinity of Evergreen extended well above 30,000 ft.

The spiral echo was also observed on the CPS–9 at Keesler AFB, Miss. from 1453 to 1516 CST. The scope camera was inoperative but a sketch of this echo made by Sgt. Kovacs of the Keesler AFB Weather Detachment is very similar to the pattern shown in figure 1. Because of the greater distance to the echo, the beam from the Keesler AFB radar was probably intersecting a somewhat higher portion of the echo than that seen by the Maxwell AFB radar.

4. SUMMARY

The spiral-shaped radar echo observed over southwestern Alabama on July 1, 1959, by the CPS–9 radars at

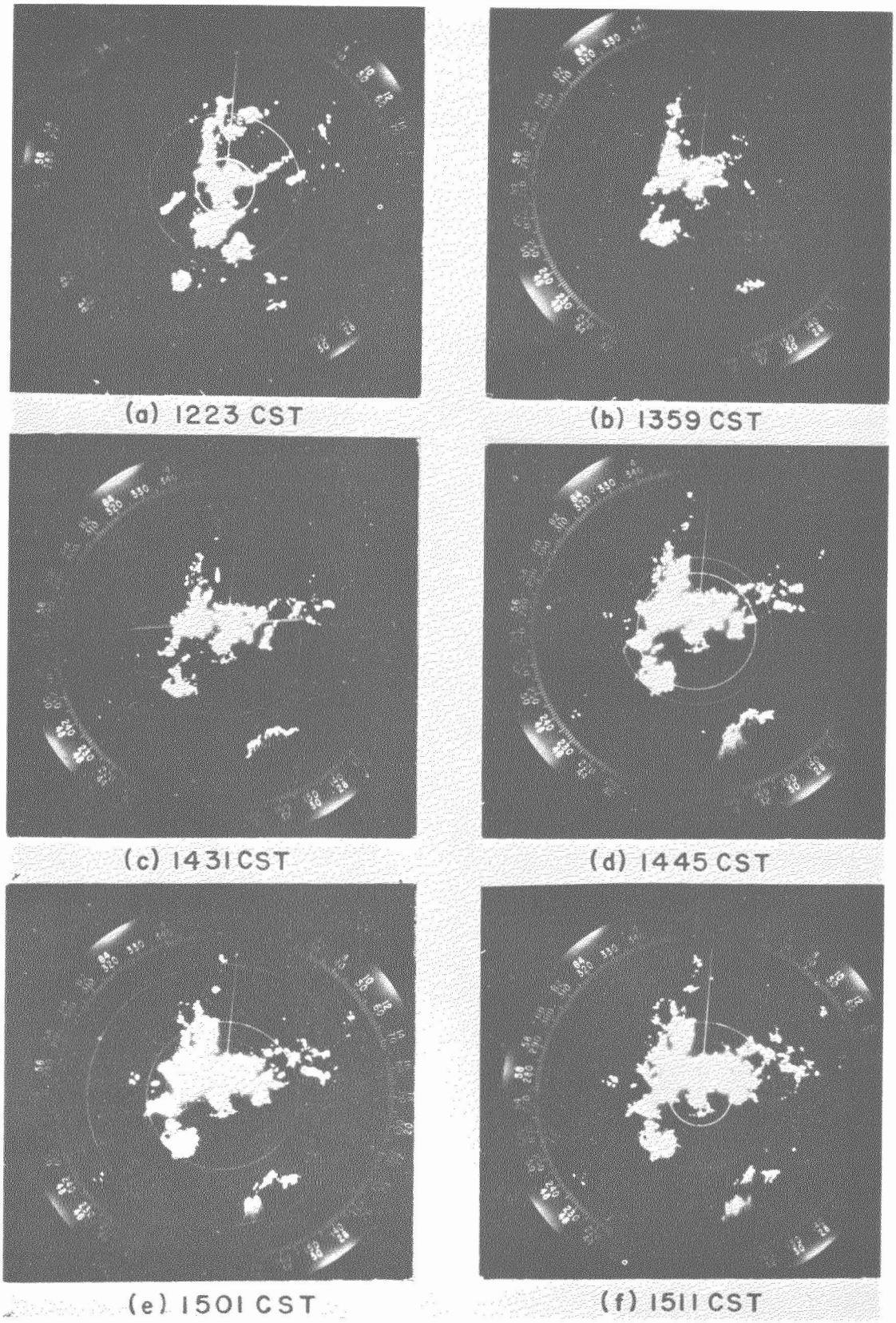

FIGURE 3.—A series of photographs of the Maxwell AFB CPS-9 PPI scope taken during the afternoon of July 1, 1959 as indicated by the times shown below the individual photographs. The 100-mile range marker is just outside the spiral echo in all the photographs. All photographs were taken with the set on long pulse (5 microseconds) with the antenna elevated one degree. All photographs were taken with the gain setting at the same value (8.0 on the arbitrary 0–10 scale provided on the CPS-9).

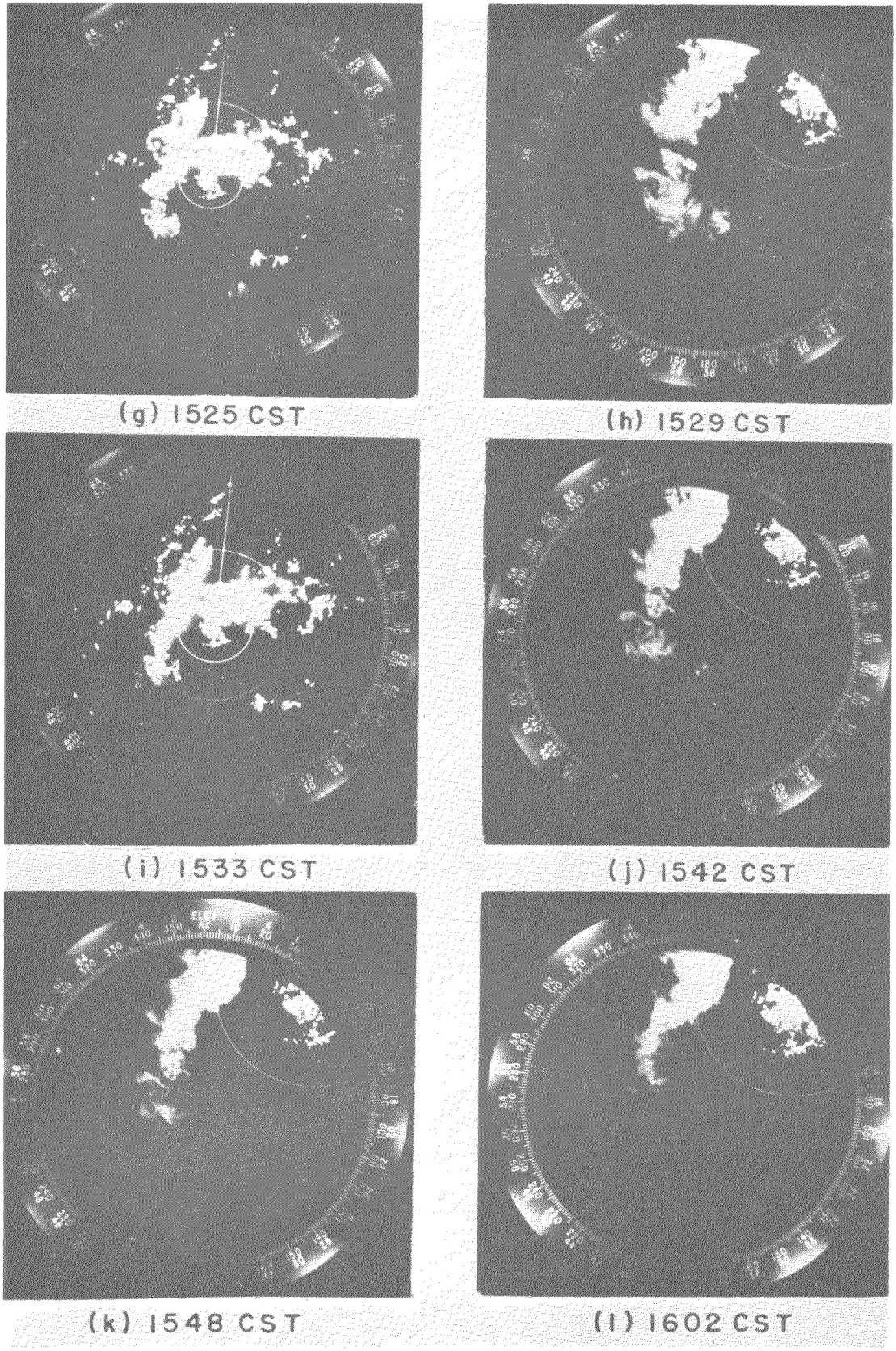

FIGURE 3.—Continued.

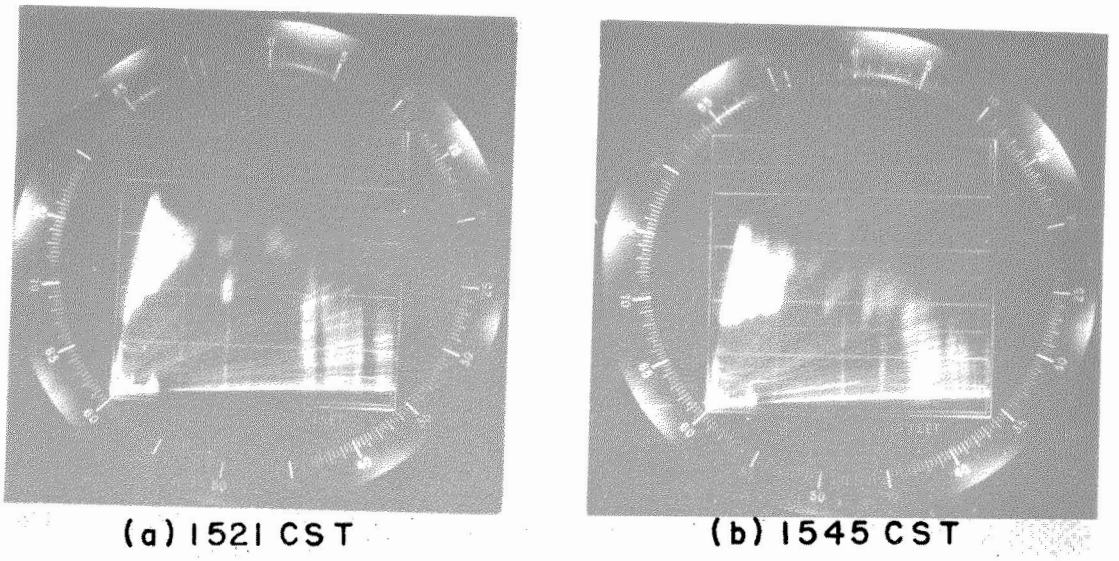

FIGURE 4.—Photographs of the range height indicator (RHI) scope of the Maxwell AFB CPS–9 taken on July 1, 1959, at the times indicated. The photographs were taken at azimuths of 236° and 240° which corresponded to the bearing of the spiral-shaped radar echo. Maximum range (horizontal scale) is 100 statute miles with range markers at 25-mile intervals and maximum altitude (vertical scale) is 50,000 ft. with height markers at 5,000-ft. intervals. The center of the vortex is about 90 miles from the station in (a) and about 95 miles out in (b).

Maxwell AFB and Keesler AFB was associated with a dissipating shower area but could not be related to any significant severe weather. A somewhat similar case was described by Soane [5] which could be related to the distribution of heavy rain. The unusual echo over southwestern Alabama was found in an area of relatively heavy rain during the earlier portion of its existence but persisted for some time in an area where the 24-hour rainfall was quite light. During this time the vertical extent of the spiral echo was also rather small in comparison with well-developed convective systems [1].

The relatively small vertical extent of the echo, as well as the suggested anticyclonic circulation, could perhaps have been used as evidence that the spiral echo was of little practical importance. However, it remains to be established whether these parameters can be used as reliable indices in evaluating the operational importance of hook-shaped or spiral-shaped radar echoes.

ACKNOWLEDGMENTS

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